Resource Management and Containment for Active Services

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Observations

- Programmable Networks Trends:
  - Not in the data plane for IP.
  - More promising in the control plane.
- Custom call processing for internet telephony is a promising area:
  - People really want it.
  - Service platforms and soft switches are shipping.
  - There is a lot of activity in standards groups (IETF, JAVA community).
  - Same resource problems as traditional Active Nets
    - Security, Accounting and Resource Control

Project Goals

- Create a user-programmable service platform for extended SIP-enabled IP Telephony Services.
- Can lessons learned from Active Networks be applied to programmable SIP call processing environments to enable user programmability?
  - Analogous to Active Networks in several ways.
  - Programmable SIP Call processing enable user injection of service code.
- Key Issues:
  - Security
  - Load and resource control
- Starting Point:
  - DARPA funded NIST Active Nets project (Virgine Galtier, Kevin Mills et al.), Active Services work.

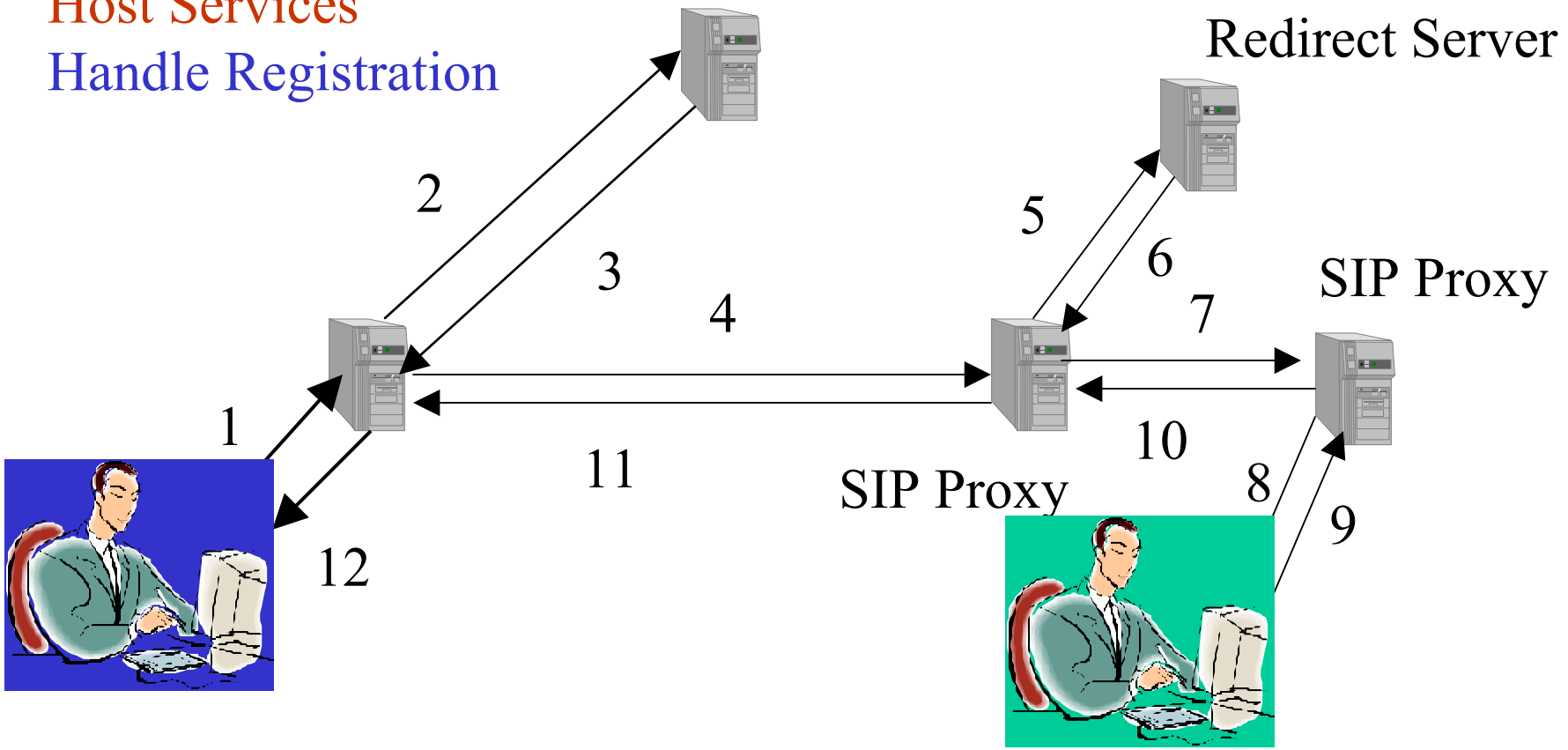
SIP and SIP services

- SIP is a HTTP-like signaling protocol for IP telephony and conferencing.
- A SIP service is an event triggered piece of code that runs on a SIP server.
- Event is generated by arrival of a message at a server or change in server state.
- Event can be:
  - low-level at the level of individual messages.
  - or semantic (at the level of a call).

SIP Network Components

SIP Proxy
Proxies SIP Invites
Host Services
Handle Registration

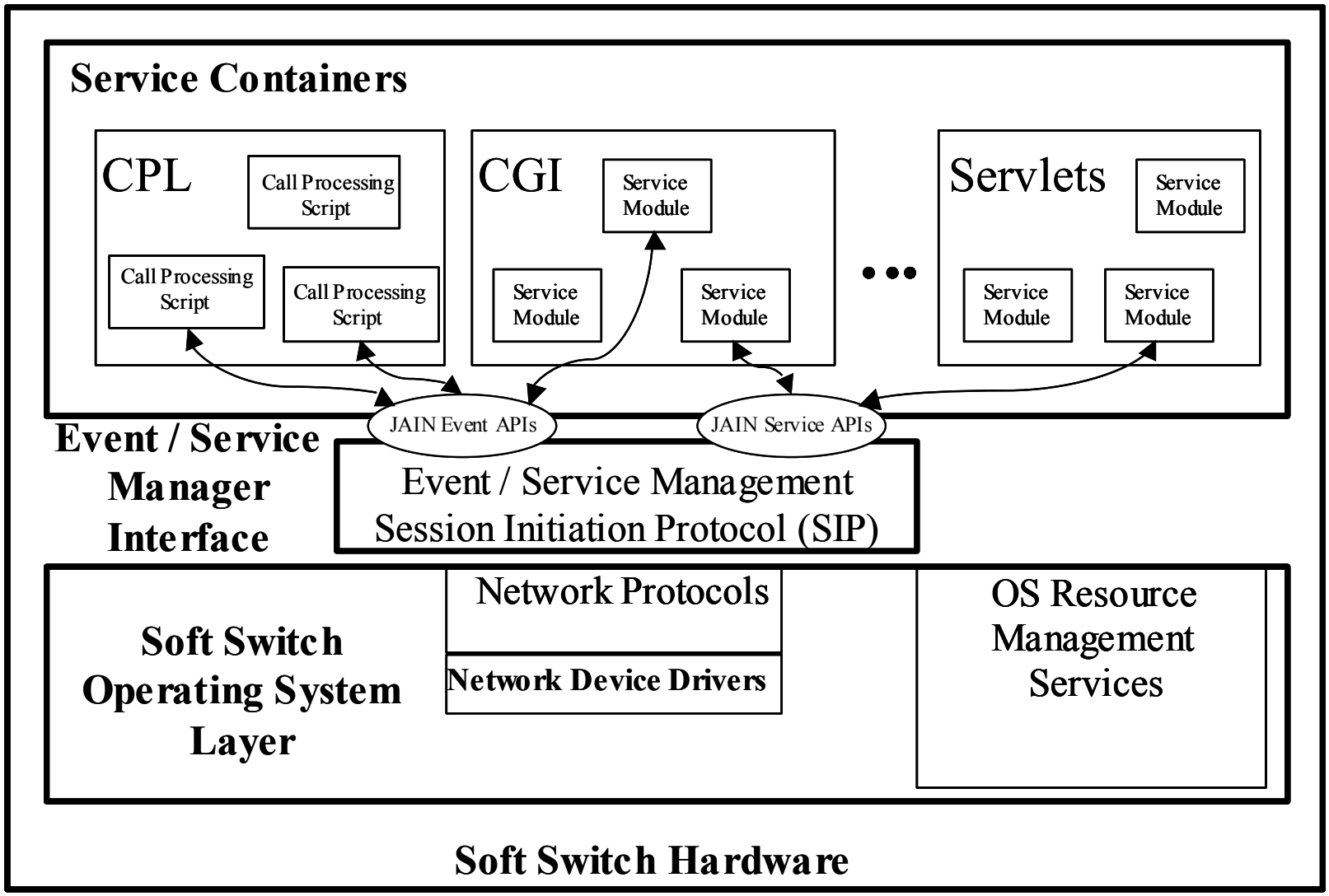
Redirect Server
Redirects Invites



User Agent Client
Send out an invitation

User Agent Server
Field the Invite

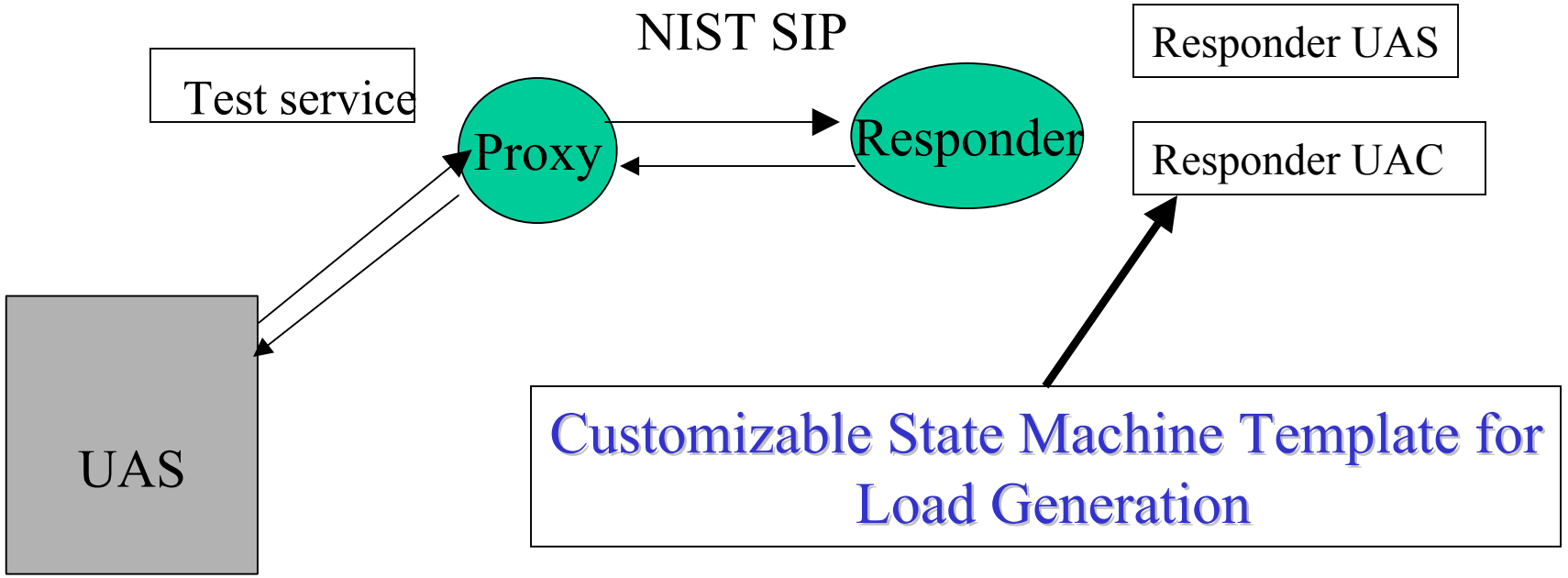
Service Architecture



SIP Services (Service Creation)

- Examples of simple programmable services:
  - Call forwarding based on time of day / caller location.
  - Call redirection based on caller.
- Much industry activity:
  - SIP CGI / SIP CPL / SIP Servlets
  - JAIN-SIP/JAIN-SIP-LITE/JAIN SCE/SCML
  - Current schemes constrain programmability for user uploaded services (e.g.. CPL).
- Our Goal:
  - Fully general User Programmable SIP Services.
  - Domains of applicability: SIP Servlets, Upload able test scripts for SIP test tool.

Driving Application:
NIST-SIP Test System



Requirements for Up-Loadable Test Scripts

- Security: Need to protect the test server from unauthorized access to resources.
- Resource containment: Need to protect the server from denial of service attacks.

Restricting access to resources

- Use existing solutions:
  - Restrict class loading.
  - Access to all sensitive resources (such as files and network) will be via resource monitors.
  - Use Security policies to define capabilities for resource access.
    - Security Manager to restrict resource access.
    - Only wrapped classes are available to service scripts.

Controlling Resource Usage of a Running Script

- Two problems:
  - Admission control: Service platform should have an interface to query the incoming service script for what resources it needs.
  - Run-time control: Service platform should be able to abort execution for misbehaving service scripts.

Generating the Resource Signature

- Resource Signature
  - A function that represents a service that can be used to determine whether or not a service will run.
  - An incoming service script declares what resources it will need by its resource signature.
- Signature can be used by container for admission control and load control.
- Signature can be generated manually by user or generated with a signature generation tool.
- Signature generation tool will:
  - Generate a function that can be called by the container to query for required resources.

Structure of a Resource Signature

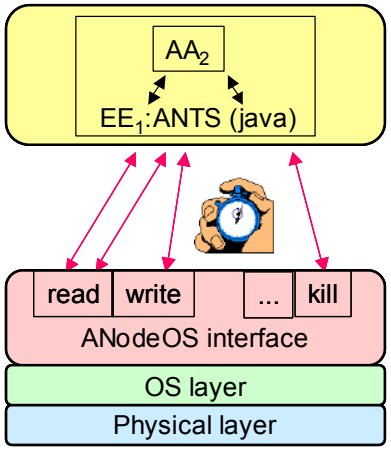
- Follow the approach developed in the previous work at NIST (Galtier, Mills et al.)
  - Application is represented by a finite state model with probabilistic transitions between states.
  - Previous project only considered CPU resources. We will extend this to include message traffic and other relevant resources.
  - Admission control of scripts is done by examining current system load and expected runtime load of the incoming script.
  - A malicious script can lie about its resource signature so we need runtime enforcement

Controlling Resource Usage of a Running Script

- Use byte code rewriting technique:
  - Determine basic blocks.
  - Call back to resource checking hooks at the end of each basic block to see if allowance has been exhausted.
  - Exit the service script if allowance has been exhausted.
    - Portable metrics such as byte code allowances will be used for CPU time representation.
    - Message count and size will be used for network.
    - Coarse grained metrics such as object allocation rate and size will be used for memory.

NIST Prior Work: Galtier, Mills et.al

Monitor at System Calls in Active Node OS → **Generate Execution Trace** → **Generate Active Application Model** →



...
begin, user (4 cc), read (20 cc), user (18 cc), write(56 cc), user (5 cc), end

begin, user (2 cc), read (21 cc), user (18 cc), kill (6 cc), user (8 cc), end

begin, user (2 cc), read (15 cc), user (8 cc), kill (5 cc), user (9 cc), end

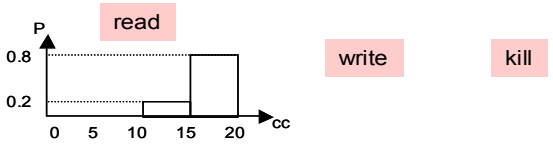
begin, user (5 cc), read (20 cc), user (18 cc), write(53 cc), user (5 cc), end

begin, user (2 cc), read (18 cc), user (17 cc), kill (20 cc), user (8 cc), end
...

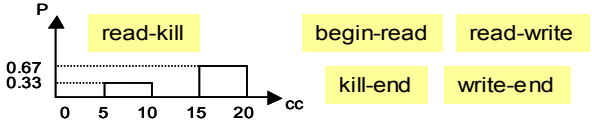
Trace is a series of system calls and transitions stamped with CPU time use

Scenario A:
sequence = "read-write",
probability = 2/5
Scenario B:
sequence = "read-kill",
probability = 3/5

Distributions of CPU time in system calls :



Distributions of CPU time between system calls :



Simulate Model with Monte Carlo Experiment → **Statistically Compare Simulation Results against Measured Data** →

Scaling AA Models

		100 bins-20000 reps	
EE	**AA**	**Mean**	**Avg. High Per.**
ANTS	Ping	0.86	0.9
	Mcast	0.40	1.9
Magician	Ping	0.44	33
	Route	0.73	13

AA model on node X:
read 30 cc
user 10 cc
write 20 cc

Model of node X:
read 40 cc
write 18 cc
user 13 cc

scale

Model of node Y:
read 20 cc
write 45 cc
user 9 cc

AA model on node Y:
read 30*20/40 = 15 cc
user 10*9/13 = 7 cc
write 20*45/18 = 50 cc

Related Work

JKernel: Uses byte code rewriting for safety. Allows users to upload HTTP servlets. http://www.cs.cornell.edu/slk/

JSeal2: Mobile agent system that uses byte code rewriting for runtime resource enforcement: http://www.jseal2.com/

KaffeOS: Process isolation and resource containment in JAVA. http://www.cs.utah.edu/flux

DARWIN : Resource management for Application Aware networks

http://www-2.cs.cmu.edu/afs/cs.cmu.edu/project/cmcl/www/darwin/

Deployment

- Developed technology will be deployed in our web test system and made available on the ABONE for experimentation.
- Resource monitoring and enforcement framework for SIP Servlets will be proposed to the JAVA community for comment and possibly incorporated into the servlet spec.
- Developed code will be distributed as part of the NIST-SIP package.
  - Already a popular package for prototyping and development (1000s of downloads).
  - Implements JAIN SIP and will incorporate Servlets.
  - Test tool already developed.

Schedules

- **Jan 2002:**
  - Exploration and evolution of the design.
- **August 2002:**
  - SIP Servlet implementation and development of resource monitor technology.
  - Release SIP Servlets as part of NIST-SIP 1.2
- **December 2002:**
  - Integration of resource monitor with the servlet engine.
  - Release SIP Servlets with resource control as part of NIST-SIP 1.3

Schedules

- **August 2003**
  - Integration into our test system
  - Gather more feedback and debug
- **December 2003**
  - Project completion and deployment on the ABONE.